RECOMMENDATION ITU-R BT.655-5

RADIO-FREQUENCY PROTECTION RATIOS FOR AM VESTIGIAL SIDEBAND TERRESTRIAL TELEVISION SYSTEMS INTERFERED WITH BY UNWANTED ANALOGUE VISION SIGNALS AND THEIR ASSOCIATED SOUND SIGNALS

(Question ITU-R 4/11)

(1986-1990-1992-1994-1995-1998)

The ITU Radiocommunication Assembly,

considering

a) that accurate protection ratio values are required in order to permit the planning of terrestrial television services in an effective manner,

recommends

1 that the protection ratios given in Annex 1 be used for planning terrestrial television services;

2 that studies should be undertaken to complete the information on protection ratios, in particular with reference to the items identified in § 4 of Annex 1.

NOTE - Systems for the emission of digital terrestrial television services are being developed and the associated protection ratios are given in Recommendation ITU-R BT.1368.

ANNEX 1

Radio-frequency protection ratios for terrestrial television systems

1 Introduction

This Annex contains general information related to protection ratios for terrestrial television systems. It also contains a series of Appendices, each containing protection ratios required for the protection of an individual category of system or signal.

Appendices 1 and 2 contain protection ratios for 525- and 625-line analogue television systems, respectively.

Appendix 3 contains protection ratios for the sound signals of analogue television systems.

2 General

The RF protection ratio is the minimum value of wanted-to-unwanted signal ratio, usually expressed in decibels at the receiver input, determined under specified conditions such that a specific reception quality is achieved at the receiver output.

Measurements of protection ratio for the vision signal of a wanted analogue television system should preferably be made with the subjective comparison method with a sine-wave reference interferer described in Recommendation ITU-R BT.1368, Annex 6.

2.1 The values of protection ratio quoted apply to interference produced by a single source. Except where otherwise stated, the ratios apply to tropospheric, *T*, interference and correspond closely to a slightly annoying impairment condition. They are considered to be acceptable only if the interference occurs for a small percentage of the time, not precisely defined but generally considered to be between 1% and 10%. For substantially non-fading unwanted signals, it is necessary to provide a higher degree of protection and ratios appropriate to continuous, *C*, interference should be used (see Annex 2). If the latter are not known, then the tropospheric, *T*, values increased by 10 dB can be applied.

Values applicable to limit of perceptibility, *LP*, are given for information only.

2.2 Significantly strong wanted input signals can require higher protection ratio values because of non-linear effects in the receiver.

2.3 For 625-line systems, the reference impairment levels are those which correspond to co-channel protection ratios of 30 dB and 40 dB with a frequency-offset between vision carriers close to two-thirds of the line frequency but adjusted for maximum impairment, the precise frequency difference being 10.416 kHz. These conditions approximate to impairment grades 3 (slightly annoying) and 4 (perceptible but not annoying) and apply to tropospheric, *T*, and continuous, *C*, interference, respectively.

2.4 It should be noted that the amplitude of a vision-modulated signal is defined as the r.m.s. value of the carrier at peaks of the modulation envelope (taking no account of the chrominance signal in positive-modulation systems), while that of a sound-modulated signal is the r.m.s. value of the unmodulated carrier, both for amplitude modulation and for frequency modulation.

For planning purposes, it may be assumed that the power in the chrominance channel does not exceed a value which is 16 dB lower than the power in the vision carrier during peaks of the modulation envelope.

2.5 The protection ratio values are not affected if digital data are included in the field-blanking interval of the unwanted television signal. However, certain values are affected in the case of a full-field data unwanted signal; in particular, it is not possible to achieve the full advantages of precision offset operation.

2.6 The relationship between the vision carrier frequencies of the wanted and unwanted signal is as follows (see Annex 3):

2.6.1 Non-controlled condition

No special control of the nominal frequency difference between the carriers of the wanted and unwanted signals.

2.6.2 Non-precision offset

The difference between the nominal frequencies of the wanted and unwanted carriers is suitably related to the line frequency, the tolerance of the carrier frequencies being ± 500 Hz.

The line synchronization of television receivers must be sufficiently immune to periodic interference if full advantage of carrier offset operation is to be achieved.

2.6.3 Precision offset (see Annex 4 for the case of 625-line systems)

The difference between the nominal frequencies of the wanted and unwanted carriers is suitably related to the line and field frequencies, but with a tolerance of each of the nominal carrier frequencies of the order of ± 1 Hz and stability of the line frequencies equal to or better than 1×10^{-6}. In order to take full advantage of precision offset when the interfering carrier falls in the upper video range (greater than 2 MHz) of the wanted signal, a line-frequency stability of at least 2×10^{-7} is necessary.

3 Synchronized carrier operation

Field and laboratory tests have demonstrated that synchronized carrier television systems allow a similar reduction in co-channel interference to that achieved by use of precision offset techniques, when the same television programme is transmitted. Ratios of wanted-to-unwanted signals of 28 dB and 38 dB were found to correspond to impairment grades of 3.5 and 4.5, respectively.

No degradation of picture quality was observed when the frequency difference between both vision carriers was less than 0.2 Hz and/or the phase fluctuations were less than 20°.

The use of synchronized carrier techniques simplifies the introduction of new television transmitters and transposers into existing networks.

Further studies in this field are required, especially for the case of different television programmes.

4 Further studies

In a number of cases, the available protection ratio values are incomplete. In particular, this applies to:

– data signals,

– out-of-channel response,

– 525-line systems,

– synchronized carrier operation,

– protection ratio values for digital television systems,

– protection ratio values for the protection of analogue television signals against interference from digital television signals.

In addition, it is necessary to establish the relationships between picture quality or impairment grade and protection ratio value. While the information is available for grades 3, 4 and 4.5, it is not yet available for lower grades.

APPENDIX 1

TO ANNEX 1

Protection ratios for 525-line television systems

1 Protection from co-channel interference

In this section, the protection ratio values between two television signals apply only for interference due to the modulated vision carrier of the unwanted signal.

1.1 Carriers separated by less than 1 000 Hz, non-controlled systems having the same or a different line-standard

Protection ratio: 45 dB, tropospheric interference.

1.2 Carriers separated by parts of the line frequency (f_{line}), systems having the same line-standard, non-precision offset (see Table 1)

TABLE 1

Protection ratio, tropospheric interference carrier separation up to about ± 36/12 f_{line} (about ± 50 kHz)

Offset of line frequency	1/2, 3/2, 5/2, ...	1/3, 2/3, 4/3, ...
525-line system (dB)	25	28

2 Protection from adjacent-channel interference

The given protection ratios apply to tropospheric interference and are defined in terms of wanted and unwanted vision carrier levels. For continuous interference, the values should be increased by 10 dB.

Adjacent-channel protection ratios cannot be determined directly from the overlapping channel protection ratio curves shown in § 4 because for certain systems the values may be affected by special measures in the receiver, e.g. sound traps.

2.1 Protection from lower adjacent-channel interference, VHF and UHF bands

The worst interference to the picture signal from another signal using the same standard results from the sound signal in the lower adjacent channel. However, an improvement of 2-3 dB can be achieved if the frequency difference between the wanted vision and unwanted sound carriers is an odd multiple of half the line frequency. During periods of no sound modulation, the improvement is as much as 10 dB.

The figure below relates to the case where the separation between the wanted vision carrier frequency and the unwanted sound carrier frequency is 1.5 MHz and the ratio between the unwanted vision and unwanted sound powers is 10 dB.

A correction must be made for different vision to sound power ratios.

Protection ratio: –13 dB.

2.2 Protection from upper adjacent-channel interference, VHF and UHF bands

Protection ratio: –10 dB.

3 Protection from image-channel interference

The protection ratio will depend on the intermediate frequency and image-channel rejection of the receiver, and on the type of unwanted signal falling in the image channel. It can be determined by subtracting the image rejection figure from the required protection ratio for overlapping channels. Table 2 shows image-channel rejection values.

TABLE 2

Image-channel rejection

Image-channel rejection (dB)	VHF	UHF
System M (Japan)	60	45
Other systems		40

4 Protection from overlapping channel interference

All figures and tables in this section give protection ratio values to be applied when a CW signal lies within the vision channel of the wanted transmission, the wanted vision signal being negatively modulated.

Corrections to be made for other types of interfering signal are given in Table 3.

Figure 1 and Table 4 show protection ratios for tropospheric interference. For continuous interference, the values should be increased by 10 dB. The unwanted signal is a CW carrier. For other types of unwanted signal, the correction factors given in Table 3 should be applied.

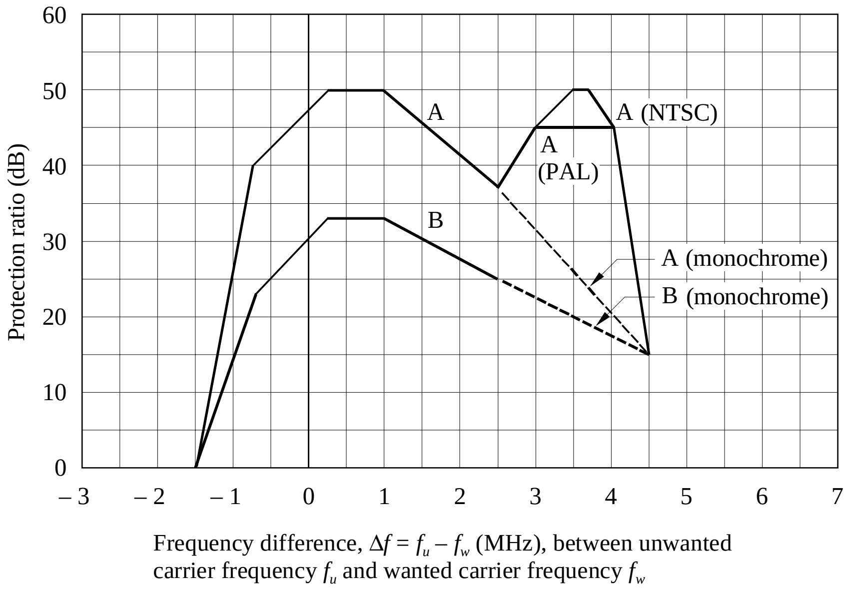
TABLE 3

Correction values for different unwanted signals

<table>
<tr><td rowspan="2">Unwanted signal / Wanted signal</td><td colspan="5">Correction factors (dB)</td></tr>
<tr><td>CW</td><td>TV-negative</td><td>TV-positive</td><td>FM-sound</td><td>AM-sound</td></tr>
<tr><td>Vision signal negative modulated</td><td>0</td><td>–2</td><td>0</td><td>0</td><td>+4</td></tr>
</table>

FIGURE 1 and TABLE 4

525-line systems (M/NTSC and M/PAL) – Tropospheric interference
Unwanted signal: CW carrier



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<table>
<tr><td colspan="2">Δf (MHz)</td><td>–1.5</td><td>–1.0</td><td>–0.75</td><td>0.3</td><td>1.0</td><td>2.5</td><td>3.0</td><td>3.5</td><td>3.7</td><td>4.1</td><td>4.5</td></tr>
<tr><td>A</td><td>NTSC (dB)</td><td rowspan="3">0</td><td rowspan="3">30</td><td rowspan="3">40</td><td rowspan="3">50</td><td rowspan="3">50</td><td rowspan="3">37</td><td rowspan="3">45</td><td>50</td><td>50</td><td rowspan="2">45</td><td rowspan="3">15</td></tr>
<tr><td>A</td><td>PAL (dB)</td><td>45</td><td>45</td></tr>
<tr><td>A</td><td>Monochrome (dB)</td><td></td><td></td><td></td></tr>
<tr><td>B</td><td>Monochrome (dB)</td><td>0</td><td>15</td><td></td><td>33</td><td>33</td><td>25</td><td colspan="2"></td><td colspan="2"></td><td>15</td></tr>
<tr><td colspan="13">Protection ratio (dB)</td></tr>
</table>

Curves A: non-controlled condition
B: non-precision offset condition
(1/3, 2/3, 4/3, 5/3, all of the line frequency)

5 Television signal affected by data signals

The inclusion of digital data such as teletext in the field-blanking interval has no effect on the required protection ratios. However, the full improvement resulting from non-precision or precision offset operation is not achievable when the unwanted signal carries a full-field data signal. No information is currently available regarding the protection ratios to be applied to a wanted 525-line system when the unwanted signal is full field teletext.

APPENDIX 2

TO ANNEX 1

Protection ratios for 625-line television systems

1 Protection from co-channel interference

In this section, the protection ratios between two television signals apply only for interference due to the modulated vision carrier of the unwanted signal. Additional protection may be necessary if the wanted sound carrier is affected, or if the unwanted sound carrier lies within the wanted vision channel (e.g. the unwanted sound carrier of system G lies within the vision channel of system K). For all protection ratio values in this section, the following corrections have to be made:

– when the wanted signal is modulated negatively and the unwanted signal is modulated positively (L/SECAM), the values should be increased by 2 dB;

– when the wanted signal is modulated positively and the unwanted signal is modulated negatively, the values should be reduced by 2 dB.

1.1 Carriers separated by less than 1 000 Hz, non-controlled systems having the same or a different line-standard

Protection ratio: 45 dB, tropospheric interference.

1.2 Carriers separated by multiples of a twelfth of the line frequency up to about ± 36/12 f_{line} (about ± 50 kHz)

These protection ratio values do not necessarily apply for greater carrier separations.

TABLE 5

Protection ratio between 625-line systems*

Offset (multiples of 1/12 line-frequency)(1)		0	1	2	3	4	5	6	7	8	9	10	11	12
Non-precision offset Transmitter stability ± 500 Hz	Tropospheric interference	45	44	40	34	30	28	27	28	30	34	40	44	45
	Continuous interference	52	51	48	44	40	36	33	36	40	44	48	51	52
	Limit of perceptibility(2)	61	60	57	54	50	45	42	45	50	54	57	60	61
Precision offset Transmitter stability ± 1 Hz	Tropospheric interference	32	34	30	26	22	22	24	22	22	26	30	34	38
	Continuous interference	36	38	34	30	27	27	30	27	27	30	34	38	42
	Limit of perceptibility(2)	42	44	40	36	36	39	42	39	36	36	40	44	48

* The values shown in Table 5 may also be applied to PALplus signals (both as wanted and/or unwanted).

(1) Value in the first column is only valid for the 0/12 case. All other values between 1/12 and 12/12 are the same by addition or subtraction of integral multiples of 12/12 up to ± 36/12.

(2) Limit of perceptibility – only for information.

2 Protection from adjacent-channel interference

The given protection ratios apply to tropospheric interference and are defined in terms of wanted and unwanted vision carrier levels. For continuous interference, the values should be increased by 10 dB.

Adjacent-channel protection ratios cannot be determined directly from the overlapping channel protection ratio curves shown in § 4 because for certain systems the values may be affected by special measures in the receiver, e.g. sound traps.

2.1 Protection from lower adjacent-channel interference

The worst interference on the picture signal from another signal, using the same standard, results from the sound signal in the lower adjacent channel. However, an improvement of 2-3 dB can be achieved if the frequency difference between the wanted vision and unwanted sound carriers is an odd multiple of half the line-frequency. During periods of no sound modulation, the improvement is as much as 10 dB.

When digital sound is introduced on System B, at a level of -20 dB relative to the vision carrier, interference to D-SECAM is not increased provided that the existing System B FM sound carrier is reduced from –10 to –13 dB relative to the vision carrier. However, further studies on this and other similar cases are needed.

2.1.1 VHF bands

The figures below relate to the cases where the separation between the wanted vision carrier frequency and the unwanted sound carrier frequency is 1.5 MHz and the ratio between the unwanted vision and unwanted sound powers is 10 dB.

A correction must be made for different vision-to-sound power ratios.

Protection ratio: for frequency-modulated sound carrier: –9 dB
for amplitude-modulated sound carrier: –8 dB.

2.1.2 UHF bands

Table 6 gives the protection required by a signal of any system against a lower adjacent-channel signal of the same or any other standard, assuming a vision-to-sound power ratio of 10 dB for unwanted signals of every standard.

A correction must be made for different vision-to-sound power ratios.

TABLE 6

Protection ratio from lower adjacent-channel interference (UHF bands) for 625-line systems

Unwanted signal / Wanted signal	Protection ratio (dB)					
	G[(1)]	H[(1)]	I[(1)]	D, K	K1	L
G	–9	–9	–9	–9	–9	–5
H	–9	–9	–9	+13	+13	+17
I	–9	–9	–9	+13	+13	+17
D, K	–9	–9	–9	–9	–9	–5
K1	–9	–9	–9	–9	–9	+17
L	–9	–9	0	–12	–12	–8

(1) The values shown for systems G, H and I may also be applied with PALplus signals as the unwanted signal.

2.2 Protection from upper adjacent-channel interference, VHF and UHF bands

Protection ratio: for systems D and K: –6 dB
for other systems: –12 dB.

3 Protection from image-channel interference

The protection ratio will depend on the intermediate frequency and image-channel rejection of the receiver, and on the type of unwanted signal falling in the image channel. It can be determined by subtracting the image rejection figure from the required protection ratio for overlapping channels. Table 7 shows image-channel rejection values.

TABLE 7

Image-channel rejection

Image-channel rejection (dB)	VHF	UHF
Systems D and K/SECAM	45	30
System D/PAL	45	40
System I		50
All other systems		40

Tables 8 and 9 give image-channel protection ratio values for the UHF bands. The wanted vision channel can be affected by the unwanted vision carrier, by the unwanted sound carrier, or by both.

The image-channel protection ratios in Tables 8 and 9 apply to tropospheric and continuous interference respectively, and are defined in terms of wanted and unwanted vision carrier levels assuming a vision-to-sound power ratio of 10 dB for every standard. A correction must be made for different vision-to-sound power ratios.

4 Protection from overlapping channel interference

All figures and tables in this section give protection ratios to be applied when a CW signal lies within the vision channel of the wanted transmission, the wanted vision signal being negatively modulated.

Corrections to be made for positively modulated wanted vision signals and for other types of potentially interfering signals are as given in Table 10.

Figures 2 to 4 and Tables 11 to 13 give protection ratio values applicable for tropospheric and continuous interference, and for limit of perceptibility. The values shown refer to the case of a wanted negatively modulated vision signal affected by an unwanted CW signal. The corrections shown in Table 10 should be applied when considering other combinations of wanted and unwanted signals.

When the unwanted signal is a television signal, two calculations of protection ratio are necessary: one for the unwanted vision carrier and one for the unwanted TV sound carrier(s). The protection ratios shown for unwanted frequency-modulated sound carriers do not apply to non-precision and precision offset conditions. Nevertheless, a reduction of 2 dB relative to the non-controlled condition (curves A and A′) is achieved within the luminance frequency range between 3/12 and 9/12 of the line frequency, and within the chrominance frequency range at 0/12, 1/12, 5/12, 6/12, 7/12, 11/12 and 12/12 of the line frequency.

TABLE 8

Protection ratios (tropospheric) from image-channel interference 625-line systems (UHF bands)

Wanted signal \ Unwanted signal		Protection ratio (dB)						Image channel	Remarks signals	
		G, H[(1)]	I[(1)]	D (PAL)	D, K (SECAM)	K1	L		Wanted	Unwanted
G (IF_v = 38.9 MHz)		–1	– 4		–12	–12	–8	$n + 9$	Vision	Sound
H (IF_v = 38.9 MHz)		–1	– 4		–9	–9	–5	$n + 9$		
I (IF_v = 39.5 MHz)		–13	–10	–10	–10	–10	–6	$n + 9$		
D (PAL) (IF_v = 38.0 MHz)		–8	–25	–20	–20	–20	–16	$n + 8$	Vision G, H: sound	Sound
		3	3	3	3	3	5	$n + 9$	Vision	Sound
D, K (IF_v = 38.0 MHz) (SECAM)		2	–15	–12	–12	–12	–8	$n + 8$	Vision G, H: sound	Sound
		13	13	13	13	13	15	$n + 9$	Vision	Vision
K1	IF_v = 40.2 MHz	7	7		7	7	9	$n + 10$	Vision	Vision
		–13	–9		–5	–5	–1	$n + 9$	Vision	Sound
	IF_v = 39.9 MHz	4	4		4	4	6	$n + 10$	Vision	Vision
		–8	–5		–2	–2	2	$n + 9$	Vision	Sound
	IF_v = 32.7 MHz	–1	0		–2	–2	2	$n – 9$	Vision	Sound
		–27	–27		–27	–27	–27	$n – 9$	Sound	Vision
L (IF_v = 32.7 MHz)		–33	–33		–33	–33	–33	$n – 9$	Sound	Vision
		–3	–2		– 4	– 4	0	$n – 9$	Vision	Sound
		<–20	<–20		<–20	<–20	<–20	$n – 8$	Vision	Vision

(1) The values shown for systems G, H and I may also be applied with PALplus signals as the unwanted signal.

The curves shown in Figs. 2 to 4 are examples that can be derived from the associated tables. They illustrate the full range of protection ratio possibilities from the worst case of non-controlled condition (curves A and A′) to the best achievable using either non-precision offset (curves B and B′) or precision offset (curves C and C′). The curves A, B and C are related to the luminance frequency range, the curves A′, B′ and C′ to the chrominance frequency range for the PAL and SECAM systems. For frequency differences below –1.25 MHz or above 6 MHz, the protection ratio can be derived by linear extrapolation to the channel limit.

TABLE 9

Protection ratios (continuous) from image-channel interference 625-line systems (UHF bands)

Wanted signal \ Unwanted signal		Protection ratio (dB) G, H(1)	I(1)	D (PAL)	D, K (SECAM)	K1	L	Image channel	Remarks signals: Wanted	Unwanted
G (IF_v = 38.9 MHz)		6	2		–5	–5	–1	$n + 9$	Vision	Sound
H (IF_v = 38.9 MHz)		6	2		–1	–1	3	$n + 9$	Vision	Sound
I (IF_v = 39.5 MHz)		– 4	–2		–2	–2	+2	$n + 9$	Vision	Sound
D (PAL) (IF_v = 38.0 MHz)		–1	–15	–10	–10	–10	–6	$n + 8$	Vision G, H: sound	Sound
		11	11	11	11	11	13	$n + 9$	Vision	Sound
D, K (IF_v = 38.0 MHz) (SECAM)		9	–10	–7	–7	–7	–3	$n + 8$	Vision G, H: sound	Sound
		21	21	21	21	21	23	$n + 9$	Vision	Vision
K1	IF_v = 40.2 MHz	15	15		15	15	17	$n + 10$	Vision	Vision
		–5	0		4	4	8	$n + 9$	Vision	Sound
	IF_v = 39.9 MHz	10	10		10	10	12	$n + 10$	Vision	Vision
		2	5		7	7	11	$n + 9$	Vision	Sound
	IF_v = 32.7 MHz	8	8		5	5	9	$n – 9$	Vision	Sound
		–26	–26		–26	–26	–26	$n – 9$	Sound	Vision
L (IF_v = 32.7 MHz)		–28	–28		–28	–28	–28	$n – 9$	Sound	Vision
		6	6		3	3	7	$n – 9$	Vision	Sound
		<–20	<–20		<–20	<–20	<–20	$n – 8$	Vision	Vision

(1) The values shown for systems G, H and I may also be applied with PALplus signals as the unwanted signal.

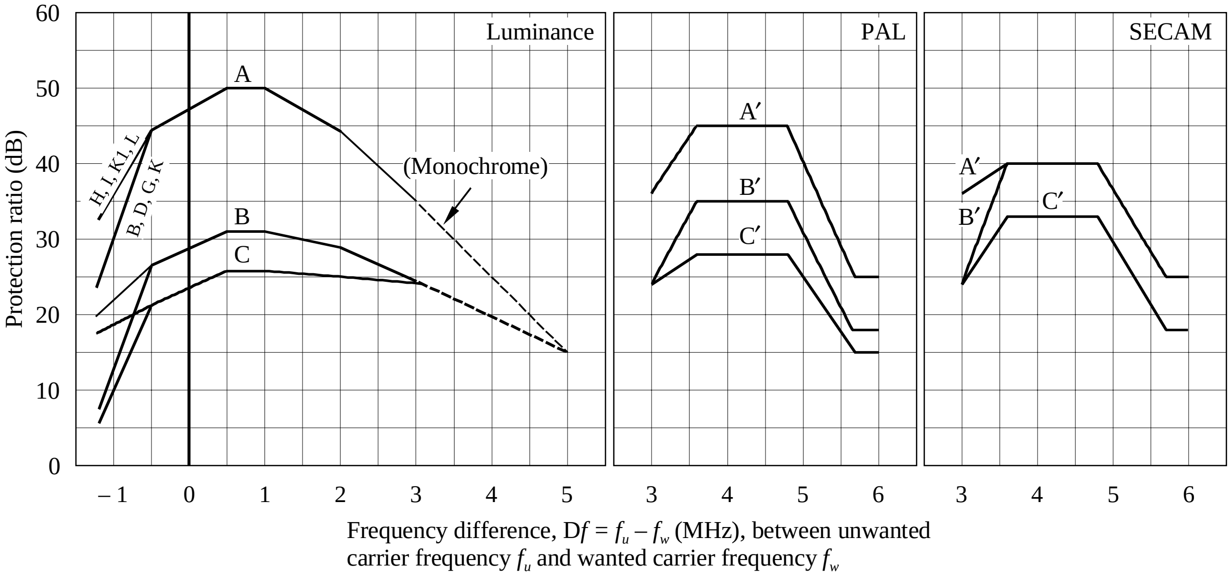
TABLE 10

Correction values for different wanted and unwanted signals

Wanted signal \ Unwanted signal	Correction factors (dB) CW	TV-negative	TV-positive	FM-sound	AM-sound
Vision signal negative modulated	0	–2	0	0	+4
Vision signal positive modulated	–2	–4	–2	–2	+2

FIGURE 2 and TABLE 11

625-line systems – Tropospheric interference



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Offset (multiples of 1/12 line-frequency)		Curve	Δ*f* (MHz)											
			Luminance range								PAL		SECAM	
			–1.25(1)	–1.25(2)	–0.5	0.0	0.5	1.0	2.0	3.0	3.6-4.8	5.7-6.0(3)	3.6-4.8(4)	5.7-6.0(3)
0	NO	A, B′	32	23	44	47	50	50	44	36	35	18	40	25
	PO	C′	23	11	32	34	40	40	37	31	28	15	33	18
1	NO		31	20	43	46	49	49	42	34	39	20	40	25
	PO		23	11	33	36	39	39	36	31	31	16	33	18
2	NO		28	17	39	42	45	45	39	32	42	22	40	25
	PO		21	9	29	32	35	35	33	29	34	17	33	18
3	NO	A′	25	13	34	36	39	39	35	29	45	25	40	25
	PO	B′	19	7	25	28	31	31	29	26	35	18	33	18
4	NO		22	10	30	32	35	35	32	27	42	22	40	25
	PO	C	17	5	22	24	26	26	25	24	34	17	33	18
5	NO		20	8	28	30	32	32	30	25	39	20	40	25
	PO	C	17	5	22	24	26	26	25	24	31	16	33	18
6	NO	B, B′	19	7	27	29	31	31	29	24	35	18	40	25
	PO	C′	17	5	24	26	28	28	26	24	28	15	33	18
7	NO	B′	20	8	28	30	32	32	30	25	35	18	40	25
	PO	C, C′	17	5	22	24	26	26	25	24	28	15	33	18
8	NO		22	10	30	32	35	35	32	27	39	20	40	25
	PO	C	17	5	22	24	26	26	25	24	31	16	33	18
9	NO		25	13	34	36	39	39	35	29	42	22	40	25
	PO		19	7	25	28	31	31	29	26	34	17	33	18
10	NO		28	17	39	42	45	45	39	32	39	20	40	25
	PO		21	9	29	32	35	35	33	29	31	16	33	18
11	NO	B′	31	20	43	46	49	49	42	34	35	18	40	25
	PO	C′	23	11	33	36	39	39	36	31	28	15	33	18
12	NO	A, B′	32	23	44	47	50	50	44	36	35	18	40	25
	PO	C′	23	11	32	40	40	40	37	31	28	15	33	18
			Protection ratio (dB)											

(1) H, I, K1, L television systems. NO: non-precision offset

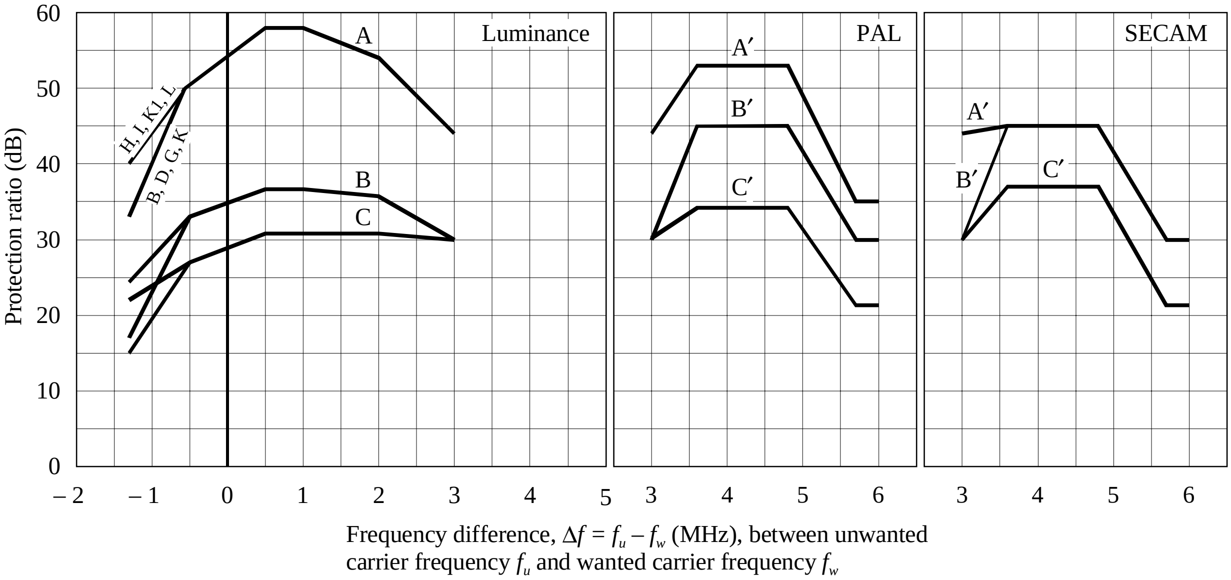
(2) B, D, G, K television systems. PO: precision offset

(3) B, G television systems: range is 5.3-6.0 MHz.

(4) D/SECAM and K/SECAM: add 5 dB.

FIGURE 3 and TABLE 12

625-line systems – Continuous interference



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Offset (multiples of 1/12 line-frequency)		Curve	Δf (MHz)											
			Luminance range								PAL		SECAM	
			–1.25(1)	–1.25(2)	–0.5	0.0	0.5	1.0	2.0	3.0	3.6-4.8	5.7-6.0(3)	3.6-4.8(4)	5.7-6.0(3)
0	NO	A, B′	40	32	50	54	58	58	54	44	45	30	45	30
	PO	C′	30	22	37	38	44	44	42	36	34	21	37	21
1	NO		38	30	49	53	57	57	53	43	48	32	45	30
	PO		29	22	38	40	42	42	41	36	36	22	37	21
2	NO		34	27	46	50	55	55	51	41	51	33	45	30
	PO		27	20	34	36	38	38	37	34	39	24	37	21
3	NO	A′	30	23	42	46	50	50	46	38	53	35	45	30
	PO		24	17	30	32	34	34	33	31	40	26	37	21
4	NO		28	21	38	42	45	45	42	35	51	33	45	30
	PO	C	22	15	27	29	31	31	31	30	39	24	37	21
5	NO		26	19	35	38	41	41	38	32	48	32	45	30
	PO	C	22	15	27	29	31	31	31	30	36	22	37	21
6	NO	B, B′	24	17	33	35	37	37	36	30	45	30	45	30
	PO	C′	23	16	29	32	33	33	32	30	34	21	37	21
7	NO	B′	26	19	35	38	41	41	38	32	45	30	45	30
	PO	C, C′	22	15	27	29	31	31	31	30	34	21	37	21
8	NO		28	21	38	42	45	45	42	35	48	32	45	30
	PO	C	22	15	27	29	31	31	31	30	36	22	37	21
9	NO		30	23	42	46	50	50	46	38	51	33	45	30
	PO		24	17	30	32	34	34	33	31	39	24	37	21
10	NO		34	27	46	50	55	55	51	41	48	32	45	30
	PO		27	20	34	36	38	38	37	34	36	22	37	21
11	NO	B′	38	30	49	53	57	57	53	43	45	30	45	30
	PO	C′	29	22	38	40	42	42	41	36	34	21	37	21
12	NO	A, B′	40	32	50	54	58	58	54	44	45	30	45	30
	PO	C′	30	22	37	44	44	44	42	36	34	21	37	21
Protection ratio (dB)														

(1) H, I, K1, L television systems. NO: non-precision offset

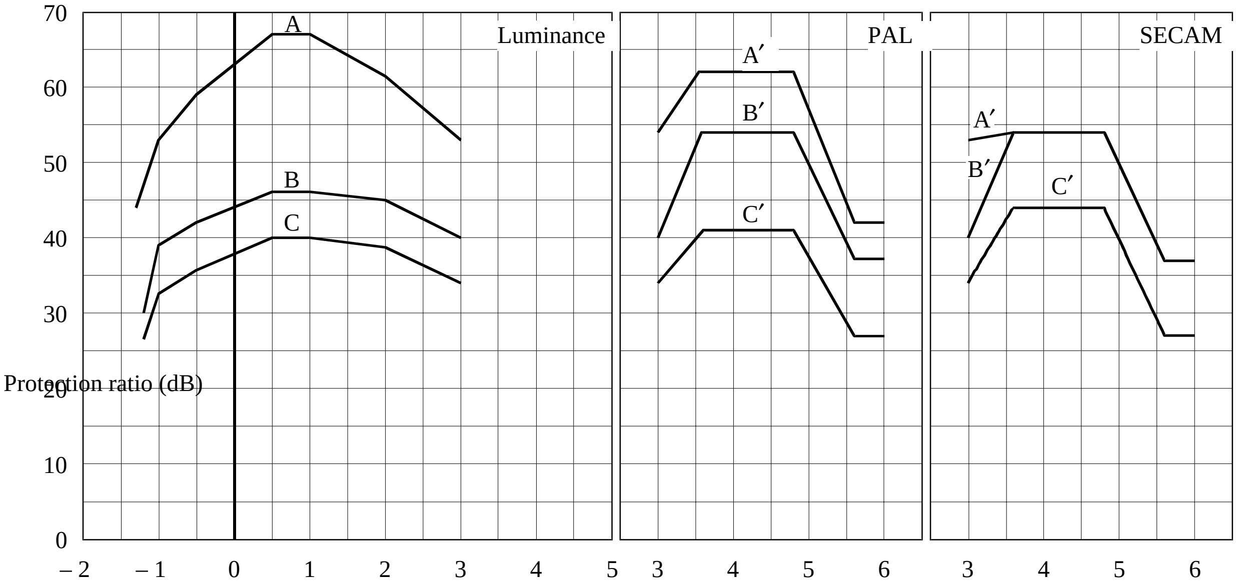
(2) B, D, G, K television systems. PO: precision offset

(3) B, G television systems: range is 5.3-6.0 MHz.

(4) D/SECAM and K/SECAM: add 8 dB.

FIGURE 4 and TABLE 13

625-line systems – Limit of perceptibility (for information only)



Frequency difference, $\Delta f = f_u - f_w$ (MHz), between unwanted carrier frequency f_u and wanted carrier frequency f_w

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<table>
<tr><td colspan="2">Δf (MHz)</td><td>–1.25</td><td>–1.0</td><td>–0.5</td><td>0.0</td><td>0.5</td><td>1.0</td><td>2.0</td><td>3.0</td><td>3.6</td><td>4.8</td><td>5.7</td></tr>
<tr><td rowspan="2">A</td><td>PAL</td><td rowspan="2">44</td><td rowspan="2">53</td><td rowspan="2">59</td><td rowspan="2">63</td><td rowspan="2">67</td><td rowspan="2">67</td><td rowspan="2">62</td><td rowspan="2">53</td><td>62</td><td>62</td><td>42</td></tr>
<tr><td>SECAM</td><td>54</td><td>54</td><td>37</td></tr>
<tr><td rowspan="2">B</td><td>PAL</td><td rowspan="2">30</td><td rowspan="2">39</td><td rowspan="2">42</td><td rowspan="2">44</td><td rowspan="2">46</td><td rowspan="2">46</td><td rowspan="2">45</td><td rowspan="2">40</td><td rowspan="2">54</td><td rowspan="2">54</td><td rowspan="2">37</td></tr>
<tr><td>SECAM</td></tr>
<tr><td rowspan="2">C</td><td>PAL</td><td rowspan="2">26</td><td rowspan="2">33</td><td rowspan="2">36</td><td rowspan="2">38</td><td rowspan="2">40</td><td rowspan="2">40</td><td rowspan="2">39</td><td rowspan="2">34</td><td>41</td><td>41</td><td rowspan="2">27</td></tr>
<tr><td>SECAM</td><td>44</td><td>44</td></tr>
<tr><td colspan="13">Limit of perceptibility (dB)</td></tr>
</table>

4.1 Protection ratios for vision signals interfered with by Terrestrial Digital Audio Broadcasting (T-DAB)

Figure 5 and Table 14 give protection ratios for negative modulated vision signals interfered with by a 1.5 MHz wide COFDM signal according to the T-DAB system (see Recommendation ITU-R BS.1114). A reduction of 2 dB should be applied for positive modulated vision signal in the range from –1 MHz to 5 MHz.

FIGURE 5

Protection ratios for vision signal interfered with by T-DAB signal

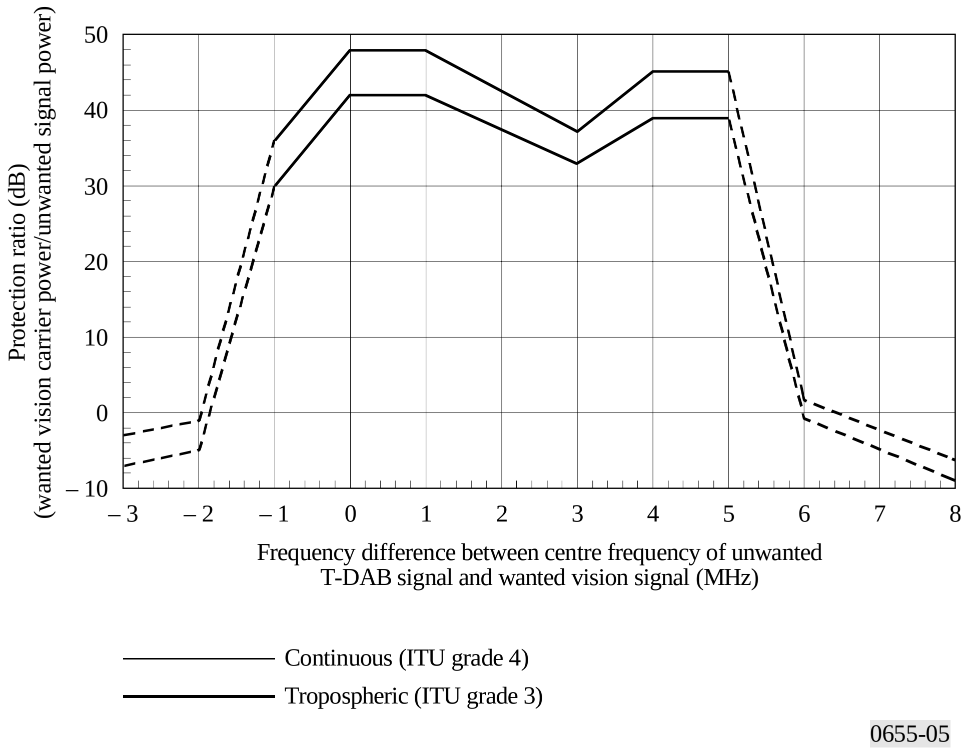


TABLE 14

Vision signal interfered with by T-DAB*

Protection ratio (dB)	Frequency difference between unwanted and wanted carriers (MHz)													
	Luminance range							Chrominance range						
	–3.0	–2.5	–2.0[(1)]	–1.0	0.0	1.0	3.0	4.0	5.0	6.0[(2)]	6.5[(3)]	7.0[(4)]	7.5[(5)]	8.0
Tropospheric interference, *T*	–7	–6	–5	30	42	42	33	39	39	–1	–3	–5	–7	–9
Continuous interference, *C*	–3	–2	–1	36	48	48	37	45	45	2	0	–2	–4	–6

* D/SECAM protection ratio values are still under study.

(1) Only B/PAL.

(2) Only B/PAL.

(3) Only B/PAL, I/PAL.

(4) Only B/PAL, I/PAL, D/PAL.

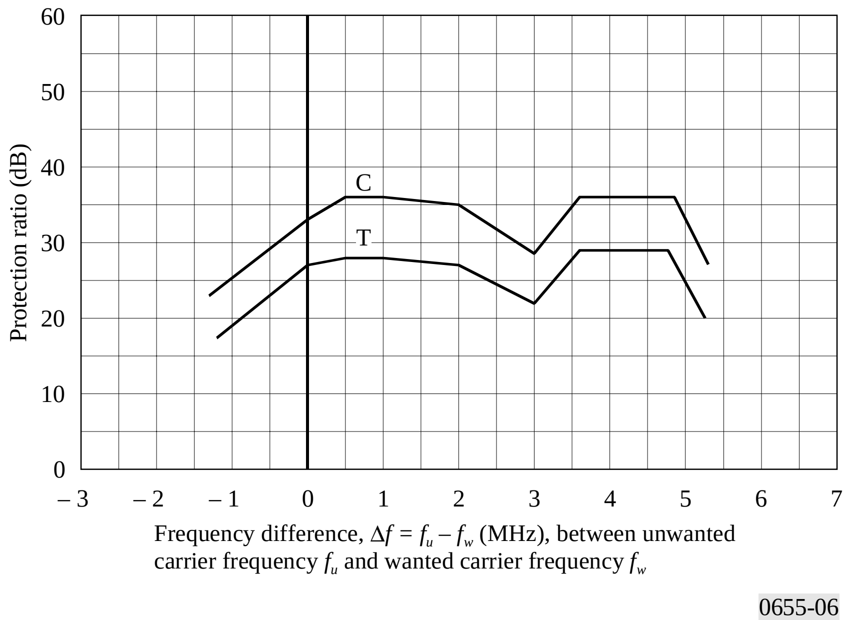
(5) B/PAL, I/PAL, D/PAL.

5 Television signal affected by data signals

The inclusion of digital data such as teletext in the field-blanking interval has no effect on the required protection ratios. However, the full improvement resulting from non-precision or precision offset operation is not achievable when the unwanted signal carries a full-field data signal. In this case, Fig. 6 shows the minimum values for all offset and non-offset conditions given in § 4. The curves in Fig. 6 apply to full-field data signals with pulse amplitude at 66% of the peak white-to-blanking level. The values should be increased linearly for higher modulation levels.

FIGURE 6 and TABLE 15

625-line systems – B/PAL and G/PAL – Protection from full-field data signals



Δf (MHz)	–1.25	0.0	0.5	1.0	2.0	3.0	3.6	4.8	5.25
Tropospheric interference, *T*	17	27	28	28	27	22	29	29	20
Continuous interference, *C*	23	33	36	36	35	29	36	36	27
Protection ratio (dB)									

APPENDIX 3

TO ANNEX 1

RF protection ratios for television sound signals

The tables in Appendix 3 show RF protection ratios for wanted FM, AM and NICAM television sound carriers interfered with by unwanted CW, FM, AM, NICAM and T-DAB signals.

All RF protection ratios in this section refer to the level of the wanted television sound carriers. The reference level of the sound carriers is the r.m.s. value of the unmodulated carrier.

The sound quality for tropospheric interference corresponds to grade 3, for continuous interference to grade 4.

The reference signal-to-noise ratios for AM and FM sound signals are:

– 40 dB (approximates to impairment grade 3) – tropospheric case;

– 48 dB (approximates to impairment grade 4) – continuous case.

The reference signal-to-noise ratios are measured as S/N peak-to-peak weighted, given in Recommendation ITU-R BS.468 and Recommendation ITU-R BS.412.

The reference FM sound signal level corresponds to a maximum frequency deviation of ±50 kHz.

The reference bit-error rates for NICAM digital sound signals are:

– BER = 10^{-4} (approximates to impairment grade 3) - tropospheric case;

– BER = 10^{-5} (approximates to impairment grade 4) - continuous case.

In the case of a two-sound carrier transmission, each of the two-sound signals must be considered separately. Multiplex modulated sound signals may require higher protection.

In each co-channel situation the wanted sound signals are directly affected by the unwanted sound signals. In addition, the unwanted vision carrier produces a phase modulation of the wanted vision carrier resulting in some sound distortion in receivers using inter-carrier demodulation techniques. It has been shown that an improvement of the sound quality can be reached by increasing the frequency offset by a suitable multiple (one, two or three) of the line frequency (see also NOTE 1 to Table 16). The weighted *S*/*N* will be improved by approximately 8 dB, if for example, 20/12th line-frequency offset is used instead of 8/12 line-frequency offset.

Table 16 gives protection ratios for a wanted sound signal interfered with by an unwanted sound signal for a frequency separation of 0 kHz.

Table 17 gives protection ratios for a wanted sound signal interfered with by an unwanted CW or FM sound carrier for several frequency separations. In the case of an unwanted negatively modulated vision signal subtract 2 dB. In the case of an unwanted AM-signal add 4 dB.

Table 18 gives protection ratios for a wanted sound signal interfered with by a T-DAB signal for different frequency separations.

TABLE 16

Co-channel protection ratios for a wanted sound signal interfered with by unwanted analogue and digital sound signals
Frequency separation 0 kHz

Protection ratio (dB) related to wanted sound carrier		Unwanted signal			
Wanted sound signal		FM/CW	AM	NICAM	T-DAB
FM	Tropospheric case	32	36	17	12
	Continuous case	39	43	27	20
AM	Tropospheric case	49	53	37	33
	Continuous case	56	60	44	40
NICAM System B/G	Tropospheric case	10	12	12	11
	Continuous case	11	13	13	12
NICAM System I	Tropospheric case				
	Continuous case				

NOTE 1 – In many cases, particularly with precision offsets, the required sound protection ratio can be higher than the protection ratio required between the vision signals according to Appendix 1. In such instances increasing the frequency offset by a suitable multiple (one, two or three) of the line frequency will decrease the required sound protection ratio significantly, the vision protection ratio remaining unchanged.

NOTE 2 – In the case of an L/SECAM signal interfered with by an I/PAL signal with digital sound, the full benefit of precision offset may not be obtained because of interference to the AM-sound signal.

TABLE 17

Protection ratios for a wanted sound signal interfered with by an unwanted CW or FM sound carrier

Wanted sound signal		Frequency difference between unwanted carrier and wanted sound carrier (kHz)			
		0	15	50	250
FM(1)	*T*	32	30	22	–6
	C	39	35	24	–6
AM	*T*	49	40	10	–7
	C	56	50	15	12
NICAM	*T*	10	10	10	5
	C	11	11	11	6

NOTE 1 – It is desirable to obtain protection ratio values for frequency differences of 10 and 25 kHz, corresponding to offsets of about 8/12 and 20/12 of the line frequency.

TABLE 18

Protection ratios for a wanted sound signal interfered with by T-DAB signal

Wanted sound signal		Frequency difference between unwanted T-DAB signal and wanted sound carrier (MHz)		
		0	0.75	1.0
FM	*T*	12	12	–8
	C	20	20	0
AM	*T*	33	33	13
	C	40	40	20
NICAM	*T*	11	11	–9
	C	12	12	–8

ANNEX 2

Tropospheric and continuous interference

When using the protection ratios in planning, it is necessary to determine whether, in particular circumstances, the interference should be considered as tropospheric or continuous. This can be done by comparing the nuisance fields for the two conditions, the nuisance field being defined as the field strength of the interfering transmitter (at its pertinent e.r.p.) enlarged by the relevant protection ratio.

Thus, the nuisance field for continuous interference:

$$E_C = E(50, 50) + P + A_C$$

and the nuisance field for tropospheric interference:

$$E_T = E(50, t) + P + A_T$$

where:

- $E(50, t)$: field strength (dB(μV/m)) of the interfering transmitter, normalized to 1 kW, and exceeded during t % of the time
- P: e.r.p. (dB(1 kW)) of the interfering transmitter
- A: protection ratio (dB)
- C and T: continuous and tropospheric interference, respectively.

The protection ratio for continuous interference is applicable when the resulting nuisance field is stronger than that resulting from tropospheric interference, that is, when $E_C > E_T$.

This means that A_C should be used in all cases when:

$$E(50, 50) + A_C > E(50, t) + A_T$$

ANNEX 3

Different offset conditions

The required protection ratio varies considerably depending on the frequency relationship between the wanted and the unwanted carriers and their frequency tolerance. The greatest protection is required when the frequency of one or both carriers is "non-controlled".

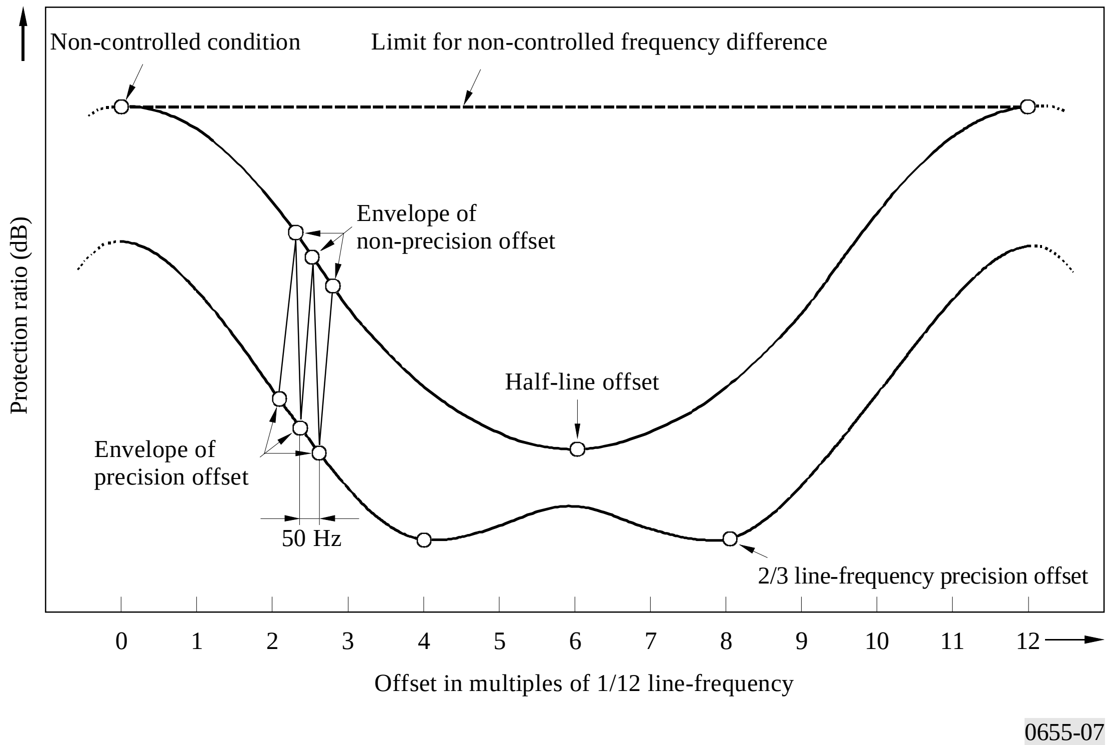
Less interference is possible and therefore lower protection ratios are required for non-precision offset (line-frequency offset). Non-precision offset takes advantage of the line frequency structure of the video signal and, in particular, it is advantageous to offset the carriers by multiples of one-half or one-third of the line frequency. The long-term stability of these favourable protection ratios can only be guaranteed, however, if the frequencies of the wanted and unwanted signals are kept constant within ± 500 Hz.

Precision offset takes further advantage of the field frequency structure of the video spectrum. The least protection is required when both carriers are "precision offset" controlled within a tolerance of ± 1 Hz for the wanted and unwanted carriers.

Figure 7 shows the main characteristics of offset operation and plots in schematic form the protection ratio curves between 0/12 f_{line} and 12/12 f_{line}. These curves are cyclic and their extensions to the left and right are symbolized by broken lines. These various conditions illustrated are similar within the luminance range up to about ± 3 MHz.

FIGURE 7

Schematic protection ratio curves with different offset positions



The upper and lower curves indicate, respectively, the protection ratios obtained with non-precision and precision offset. More precisely, these two curves trace the envelope of a series of fluctuations in the protection ratio which swings between the two curves at field frequency as represented by the thin line.

Co-channel protection ratio curves in the vicinity of 0/12, 4/12 and 6/12 line frequency (625-line systems)

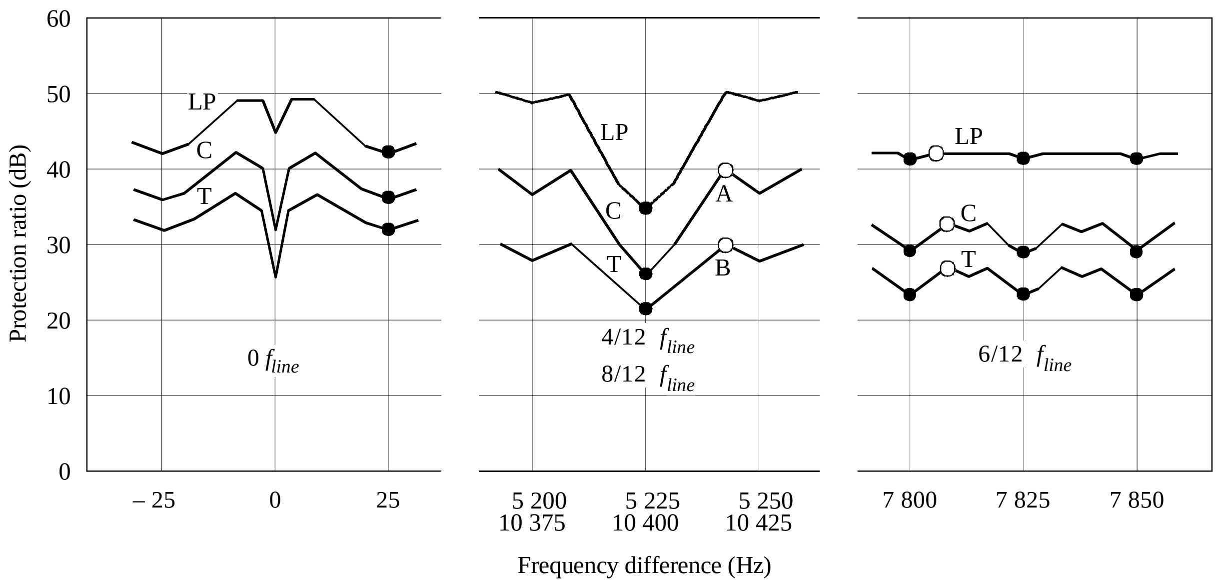
Figure 8 gives examples of protection ratio curves for the three most important offset positions (0/12, 4/12 and 6/12 f_{line}). The curves in each graph relate to tropospheric interference, continuous interference and the limit of perceptibility.

The white and black points indicate the positions for non-precision and precision offset respectively. The reference impairment points for tropospheric and continuous interference are also indicated in the figure.

When operating TV transmitter networks with synchronized as well as phase-locked carriers, the protection ratio values are slightly reduced.

FIGURE 8

Precise structure of the protection ratio curves for different offset positions



Curves T: tropospheric interference
C: continuous interference
LP: limit of perceptibility

A: continuous interference reference point
B: tropospheric interference reference point

○ Non-precision offset
● Precision offset

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ANNEX 4

Frequencies for precision offset

1 Introduction

Table 19 lists the possible frequencies for precision offset in the vicinity of each twelfth of line frequency. For the luminance frequency range, the frequencies shown in the table end with 25 Hz up to 6/12 f_{line} and with 100 Hz beyond this frequency. Two possibilities are shown for 6/12 f_{line} (7 800 and 7 825 Hz) because at this point the spectral lines are symmetrical and thus of the same amplitude. The offset frequencies are expressed in twelfths of line frequency.

Alternative frequencies in the vicinity of each offset position, which differ by integral multiples of 50 Hz and by integral multiples of 15 625 Hz from the values given, are possible. The term “precision offset” always refers to a difference between the true frequencies of the wanted and unwanted transmitters, and not to an offset of a transmitter from its nominal carrier frequency.

If the frequency difference between wanted and unwanted carrier exceeds the normalized range specified in Table 19, one has to subtract integral multiples of 15 625 Hz. For computer calculations, formulae are given below for all precision-offset frequency differences in the luminance and in the chrominance range for 625-line systems.

2 Normalized precision offset between 0/12 and 12/12 of line frequency

2.1 Luminance range for all 625-line systems:

$$f_p = 15\,625\, m \pm 25\,(2\,n + 1)$$

$m \leq 192, \quad n \leq 156$

with *m* and *n* integers.

2.2 Chrominance range only for PAL and SECAM systems

2.2.1 PAL systems

$$f_p = 15\,625\, m \pm 25\,(2\,n + 1) + k$$

$m \geq 216$ and

$k = -20$ for $0 \leq n < 143$

$k = -15$ for $143 \leq n < 169$

$k = -5$ for $169 \leq n < 299$

$k = +5$ for $299 \leq n \leq 312$.

2.2.2 SECAM systems

$$f_p = 15\,625\, m + 2n \left(25 + \frac{25}{624}\right)$$

with *m*, *n* and *k* integers.

TABLE 19

Offset (multiples of 1/12 line-frequency)	Precision offset frequency (Hz)		
	Luminance range	Chrominance range	
		PAL	SECAM
0	25	5	0
1	1 325	1 305	1 302
2	2 625	2 605	2 604
3	3 925	3 905	3 906
4	5 225	5 205	5 208
5	6 525	6 505	6 510
6	7 800 or 7 825	7 810	7 812
7	9 100	9 115	9 115
8	10 400	10 420	10 417
9	11 700	11 720	11 719
10	13 000	13 020	13 021
11	14 300	14 320	14 323
12	15 600	15 630	15 625

3 Computation of operational offset frequencies in a network with transmitter triplets

Precision offset techniques are usually introduced to provide solutions of particular interference problems between two co-channel transmitters. In operational television networks, co-channel transmitters are situated at the corner of a triangle. A typical line offset (non-precision offset) situation for such a transmitter triplet is: nominal vision carrier frequency –2/3 f_{line}, ± 0 f_{line}, and +2/3 f_{line} or in twelfths: 8M, 0, 8P (M = minus; P = plus). A transmitter triplet A-B-C consists of three transmitter pairs A-B, A-C and B-C. Introduction of precision offset for the above-mentioned example means a possible reduction of interference for all three pairs of the transmitter triplet. In practice, only 35% of all the theoretically possible transmitter triplets have full improvement for all three pairs, the residual 65% triplets have one or two pairs in non-precision offset.

Table 20 shows a complete and normalized list of these 35% possible cases within the range between 0P and 12P which secure an improved interference situation for all three transmitter pairs within a triplet, when precision offset is used.

With a simple rule, determination of precision offset frequencies for transmitter triplets is possible. All transmitter triplets which cannot translate to the normalized cases of Table 20 contain at least one pair without precision offset.

3.1 Example

The aim of this calculation is the transformation of all three offset positions into the range between 0P and 12P (see Table 20). Each single transmitter can be moved by multiples of line frequency, that is, by multiples of 12/12 (see Step 2). Moving of any twelfths is allowed, when all transmitters are moved by the same number of twelfths (see Step 1).

	A	B	C
Given: Transmitter triplet			
Line offset position:	18M	8P	2P
Step 1			
Set one transmitter to 0 by linear translation:	+18	+18	+18
Result:	0	26P	20P
Step 2			
Translation of transmitter B and C into the range between 0P and 12P by subtracting or adding multiple of the line frequency:		–24	–12
Result:	0	2P	8P
Step 3			
Selection of precision offset frequencies from Table 20:	0	2 625	10 400 Hz
Step 4			
Step 2 has to be compensated:		+31 250	+15 625 Hz
Result:	0	+33 875	+26 025 Hz
Step 5			
Step 1 has to be compensated:	–23 400	–23 400	–23 400 Hz
Result:	–23 400	+10 475	2 625 Hz
equivalent to	18M	8P*	2P

TABLE 20

Possible offset combinations allowing precision offset for all transmitter pairs in transmitter triplets

Case	Offset			Frequency (Hz) (625-line systems)		
1	0	0P	6P	0	25	7 800
2	0	0P	6P	0	25	7 825
3	0	1P	6P	0	1 325	7 800
4	0	1P	7P	0	1 325	9 100
5	0	2P	6P	0	2 625	7 800
6	0	2P	7P	0	2 625	9 100
7	0	2P	8P	0	2 625	10 400
8	0	3P	06P	0	3 925	7 800
9	0	3P	07P	0	3 925	9 100
10	0	3P	08P	0	3 925	10 400
11	0	3P	9P	0	3 925	11 700
12	0	4P	6P	0	5 225	7 800
13	0	4P	07P	0	5 225	9 100
14	0	4P	08P	0	5 225	10 400
15	0	4P	09P	0	5 225	11 700
16	0	4P	10P	0	5 225	13 000
17	0	5P	06P	0	6 525	7 800
18	0	5P	07P	0	6 525	9 100
19	0	5P	08P	0	6 525	10 400
20	0	5P	9P	0	6 525	11 700
21	0	5P	10P	0	6 525	13 000
22	0	5P	11P	0	6 525	14 300
23	0	6P	6P	0	7 800	7 825
24	0	6P	7P	0	7 825	9 100
25	0	6P	8P	0	7 825	10 400
26	0	6P	9P	0	7 825	11 700
27	0	6P	10P	0	7 825	13 000
28	0	6P	11P	0	7 825	14 300
29	0	6P	12P	0	7 800	15 600
30	0	6P	12P	0	7 825	15 600

* To reduce the sound interference between transmitters B and C, an offset position of 20P = 26 100 Hz (enlarged by 12P = 15 625 Hz) would be preferable. In this case picture interference is unchanged.